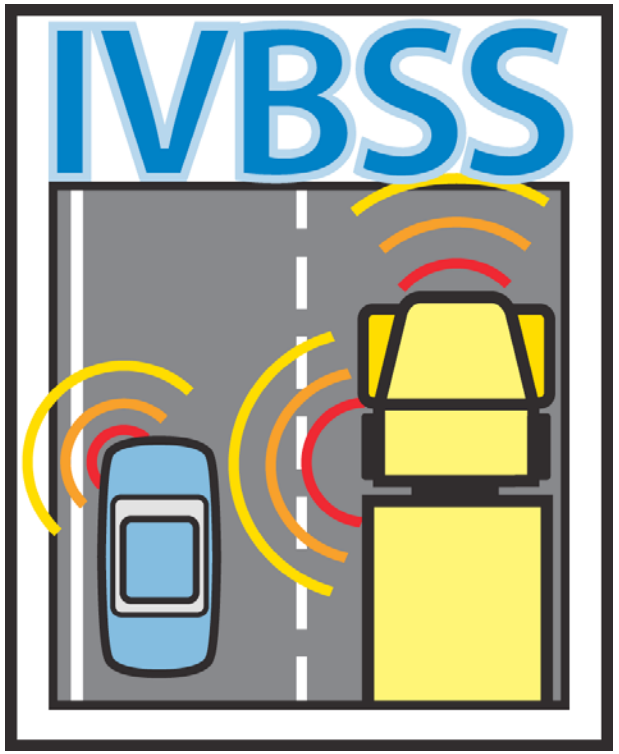


Integrated Vehicle-Based Safety Systems (IVBSS) Initiative

Chris Flanigan
FMCSA Office of Analysis, Research, and Technology

Webinar—October 29, 2008

What is the IVBSS Program?

- University of Michigan Transportation Research Institute (UMTRI)-led cooperative agreement with U.S. Department of Transportation (DOT)
  - National Highway Traffic Safety Administration (NHTSA) and Federal Motor Carrier Safety Administration (FMCSA)
- Develop integrated crash warning systems in light vehicles and heavy trucks to estimate safety benefits and driver acceptance
- 54-month, 2-phase, $32.2M program
  - $25M from U.S. DOT, $7.2M from the partners

IVBSS Phase I and II

- Phase I (Years 1 and 2)
  - identify crash problem (develop scenarios)
  - functional requirements
  - system performance guidelines
  - develop and conduct verification tests (test track and on-road)
- Phase II (Years 3 and 4)
  - build vehicle fleets and verify performance
  - conduct extended pilot test
  - conduct field operational test of ten trucks

IVBSS Subsystems

- Forward crash warning
  - Address rear-end crashes
- Lateral drift warning
  - Address lane/road departure crashes
- Lane change/merge warning
  - Address lane change crashes

NHTSA/FMCSA

Volpe & NIST

UMTRI

Light Vehicle Platform

Heavy Truck Platform

Takata

Michigan DOT

Visteon

Honda

Eaton

International

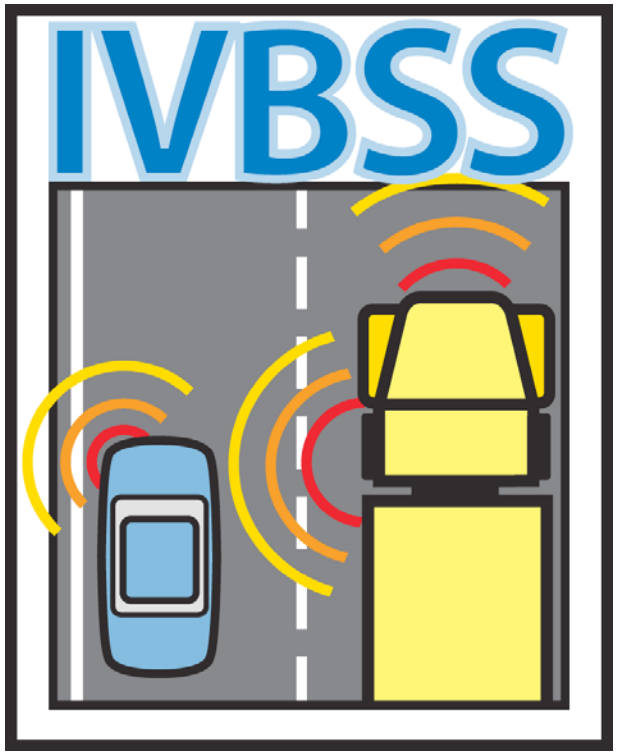
Con-Way

Battelle

IVBSS Partnership

Solid lines indicate subcontracts and working relationships

Dashed lines indicate working relationships only (no contracts)



Heavy Truck Platform

Overview

- Design, develop, verify and implement in heavy trucks an integrated crash warning system that addresses:
  - Rear-end crashes
  - Lane departure crashes
  - Lane change/merge crashes
- It will appear to drivers as a single system with an associated, integrated Driver Vehicle Interface (DVI)

Scope of IVBSS Requirements

- Autonomous system
- No active vehicle control
- Technologies must be available for field operational test (FOT)

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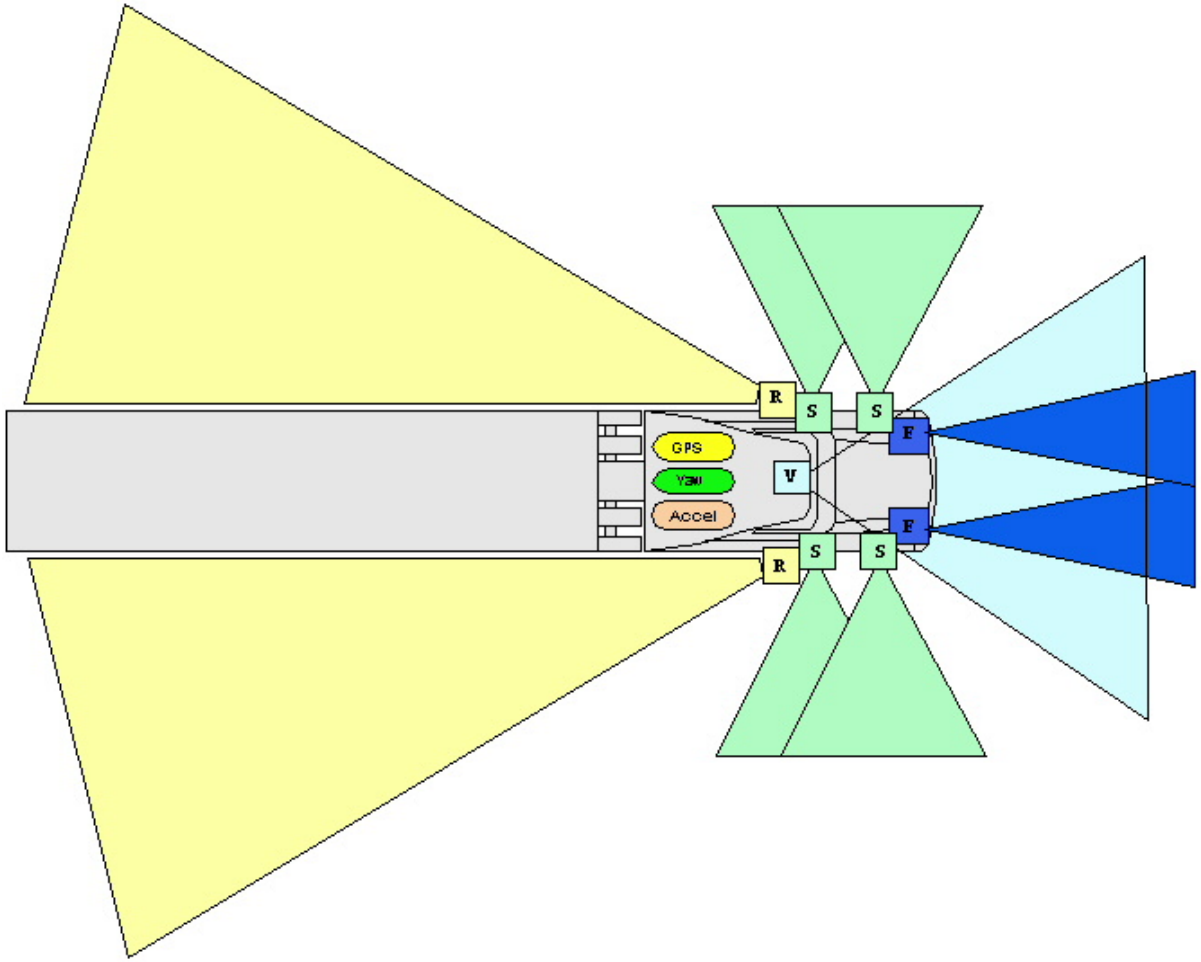
Systems Engineering

- Sensor descriptions
  - Tractor-only solution
- Subsystem descriptions
- Driver Vehicle Interface
- Objective Testing

Heavy Truck Sensor Suite

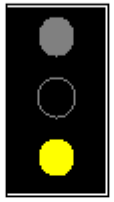
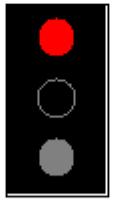
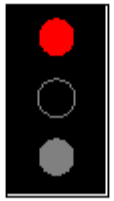


Radar and Vision Sensor Key:	
R	Rear Radar Sensor
S	Side Radar Sensor
F	Forward Radar Sensor
V	Short Range Vision Sensor

LCM Concept of Operation

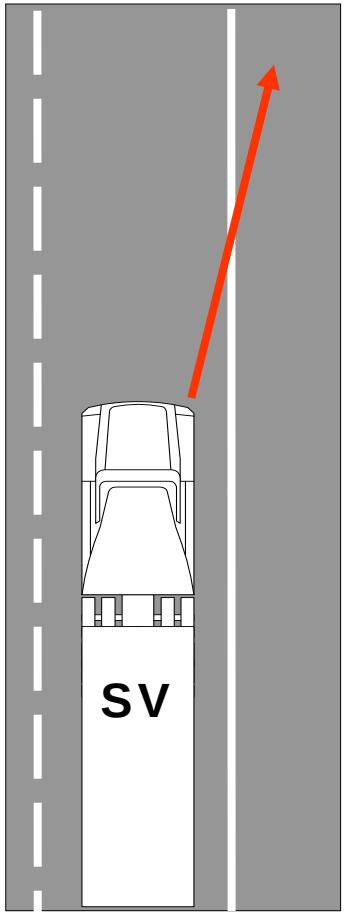
- Provides side object presence indicators to the driver and warnings of unsafe maneuvers
- Directional side visual display and directional auditory display
- Consistent with LDW warning display
- Combination of MA/COM radars and Backspotter radars

LCM General Operation

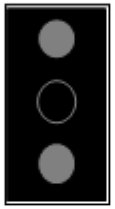
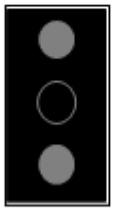
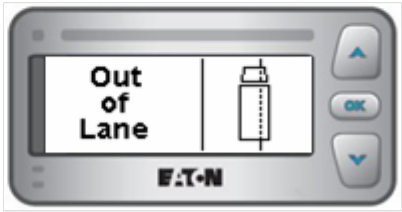
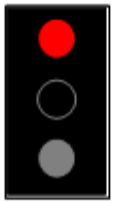
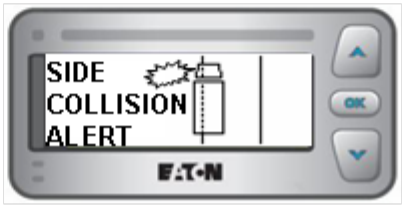
Cond. Code	Initiation Condition	Visual Displays Side	Visual Displays Forward	Auditory Display (Directional)
LCM-0	No vehicle detected adjacent to subject vehicle			None
LCM-1	Adjacent vehicle detected (use caution)			None
LCM-2	Adjacent vehicle detected AND corresponding turn signal is active AND lane change maneuver NOT detected			None
LCM-3	Adjacent vehicle detected AND lane change maneuver IS detected			Right/Left channel side collision warning

LDW Concept of Operation

- Track lane boundaries
- Measure vehicle position and lateral velocity relative to lane
- Assess threat of lateral departure to warn driver when they are about to depart lane.



LDW General Operation

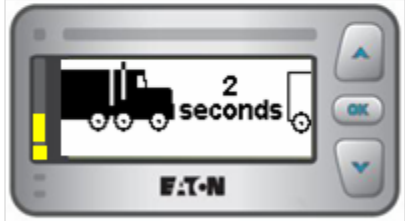
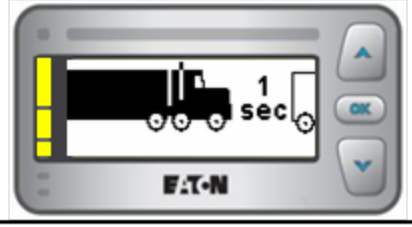
Initiation Condition	Visual Displays		Auditory Display
	Side	Forward	
Normal Driving - Good boundaries Vehicle maintaining lane position, nothing nearby, good marker on both sides.			None
Normal Driving - Missing left boundary Vehicle maintaining lane position, nothing nearby, good marker on right, missing marker on left.			None
Departure into Clear Space Lane departure in the absence of object in adjacent region. Turn signal off, dashed or solid lane boundary			Directional lane excursion warning
Departure into Occupied Space Lane departure with object detected in adjacent region. Dashed or solid lane boundary. **Same as LCM warning**			Directional side collision warning

LDW Availability

FCW Concept of Operation

- Includes both a headway warning system and an imminent collision detection system
- Provides drivers with graded cautionary warnings when headway time to a forward object drops below four established threshold levels
- Provides collision warnings whenever a significant risk of collision is detected

FCW Warning Logic Detection & Headway Alerts

Code	Initiation Condition	Forward Display	Auditory Display
FCW-1	Forward object detected		None
FCW-2	Forward object within 3s headway (and no higher priority alert) AND opening OR closing		None
FCW-3	Forward object within 2s headway (and no higher priority alert) AND opening OR closing		Opening=None Closing=Short Alert
FCW-4	Forward object within 1s headway (and no higher priority alert) AND opening OR closing		Opening=None Closing=Double Alert

Note: Headway alerts provided when SV speed is greater than 10 mph

FCW Warning Logic Collision Alerts

Code	Initiation Condition	Forward Display	Auditory Display
FCW-5	Forward object within 0.5s headway AND closing		Repeating Alert
FCW-6	Slow moving vehicle alert		Repeating Alert
FCW-7	Stationary vehicle/object alert		Double Alert

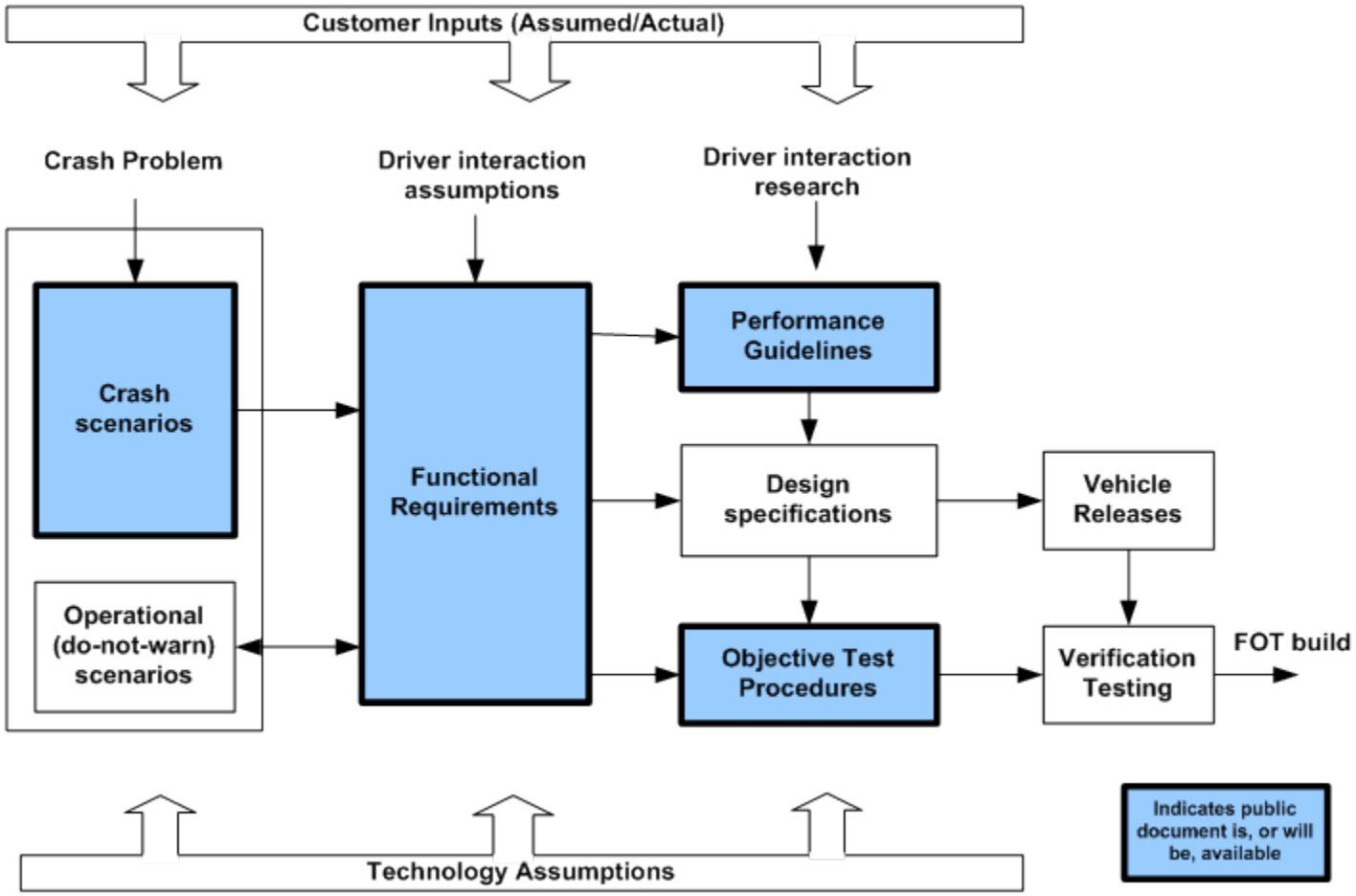
Arbitration

- Develop a rule-based approach
  - use simple ratings of message priorities to support rule development
- More complex rules and exceptions to the rules requires taking into account:
  - vehicle kinematics
  - cues to driver alertness
  - indications of driver awareness of the threat
  - crash risks

DVI Concept of Operation

- Focus is on supporting a timely and appropriate response from the driver
- Integration should support the development of an accurate and functional mental model of the IVBSS
- Support the driver in avoiding errors, distraction, confusion, and information overload
- Heavy truck drivers are significantly different than passenger car drivers—they have formal training

Development Process – Heavy Truck Platform



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Objective Testing Truck Setup

Sensor/Camera Locations

Rear-looking M/A-Com radars

Forward-looking AC20 radars

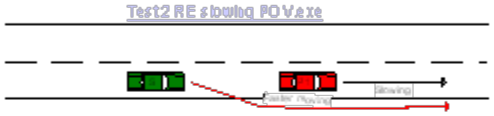
Forward-looking camera

Backspotter radars

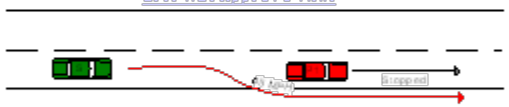
Track Tests

Rear-end verification Tests

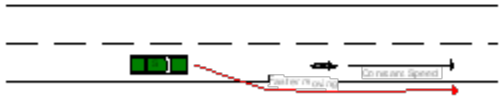
2.1 Rear End with constant speed P1



2.2 Rear End with slowing P1

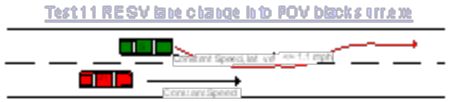


2.3 Rear End with Stopped P1



2.9 Rear End with Slower Moving Motorcycle

Lane-Change Verification Test Guidelines

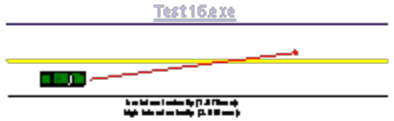


3.1 Lane Change into Adjacent P1

3.3 Lane Change into adjacent P1 vehicle on Merge

3.5 Lane Change into Approaching P1 vehicle

Road Departure Verification Test Procedures



4.1 Road Departure toward Opposing Traffic Lane

4.2 Road Departure Toward Clear Shoulder

4.3 Road Departure Toward Clear Shoulder on Curve

4.5 Road Departure Toward Curve with Excessive Speed

Multiple Threat, On-Road, & No-Warn

Phase II – Early Tasks

- Complete final vehicle integration design
- Launch vehicle fleet builds
- Integrate final FOT data acquisition system
- Tune system further to reduce false alerts

Heavy Truck (HT) FOT Scope

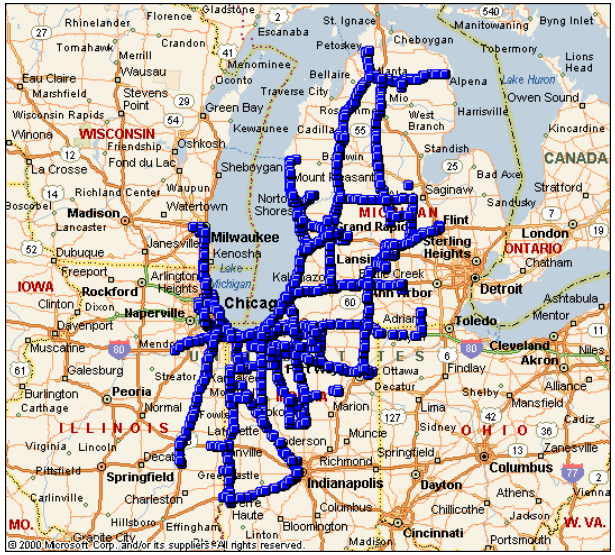
- Testing will occur over a ten month period
- The volume of data would represent approximately 8 years of HT driving data
- A data server will be installed at the HT fleet distribution center
  - Approximately 600GB of data expected

Fleet Location

- FOT will be run out of Con-Way Freight's Romulus, MI terminal
  - Includes MI's lower peninsula, northern Ohio/Indiana, and Chicago
  - Local P&D is 41% limited access highway
  - Line-haul is 96% limited access highway
  - Estimated total mileage exposure for FOT fleet is 82% limited access, 18% service roads
- Driver age is from 25–65 (all male)

Heavy Truck FOT Data

- Subjective data
  - Questionnaires, focus groups, debriefings
- Objective data
  - Multi-CPU DAS that is unobtrusive
  - Full-time dataset describing:
    - Vehicle performance
    - Driver performance
    - Vehicle location
    - Driving environment



FMCSA's Role

- Assure safety of commercial heavy trucks
  - encourage deployment of safety equipment that is deemed beneficial to heavy truck safety
  - assure safety is not adversely affected by overloading heavy truck operators with information
- Assure IVBSS accounts for unique requirements of operating heavy trucks
  - e.g., headway information critical for heavy truck drivers due to evasive capabilities

Program Status

- Completed Phase I
  - HT systems passed verification tests
- Public meeting on results in April 2008
  - http://www.its.dot.gov/ivbss/ivbss_2008pm.htm
- Phase II kickoff meeting held in June 2008
- Track and on-road tests completed in October 2008
- Extended pilot test to start in November 2008
- Field operational test to start in early 2009

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http://www.its.dot.gov/ivbss/